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BOX: PATENT APPLICATION
Assistant Commissioner for Patents
Washington, D.C. 20231

Re: Application of **Yoshiaki INOUE**
METHOD OF TONE REPRODUCTION WITH HALFTONE DOTS, APPARATUS FOR OUTPUTTING HALFTONE PLATE, HALFTONE PLATE, AND PRINTED MATERIAL
Our Reference: Q58052

Dear Sir:

Attached hereto is the application identified above including the specification, claims, executed Declaration and Power of Attorney, eleven (11) sheets of drawings, one (1) priority document, Information Disclosure Statement, PTO Form 1449 with reference, executed Assignment and PTO Form 1595.

The Government filing fee is calculated as follows:

Total Claims	12 - 20 =	0 x $18 =	$ 000.00
Independent Claims	4 - 3 =	1 x $78 =	$ 78.00
Base Filing Fee	($690.00)		$ 690.00
Multiple Dep. Claim Fee	($260.00)		$ 000.00
TOTAL FILING FEE			**$ 768.00**
Recordation of Assignment Fee			$ 40.00
TOTAL U.S. GOVERNMENT FEE			**$ 808.00**

Checks for the statutory filing fee of $ 768.00 and Assignment recordation fee of $ 40.00 are attached. You are also directed and authorized to charge or credit any difference or overpayment to Deposit Account No. 19-4880. The Commissioner is hereby authorized to charge any fees under 37 C.F.R. 1.16 and 1.17 and any petitions for extension of time under 37 C.F.R. 1.136 which may be required during the entire pendency of the application to Deposit Account No. 19-4880. A duplicate copy of this transmittal letter is attached.

Priority is claimed from:

Japanese Patent Application	**Filing Date**
Patent Application No. 11-141921	May 21, 1999

Since the anniversary of the priority date fell on a Sunday, the filing of this application on Monday, May 22, 2000, is sufficient to obtain the benefit of priority.

Respectfully submitted,
SUGHRUE, MION, ZINN, MACPEAK & SEAS
Attorneys for Applicant(s)
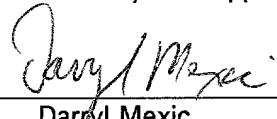
By _____
Darryl Mexic
Registration No. 23,063

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METHOD OF TONE REPRODUCTION WITH HALFTONE DOTS, APPARATUS FOR OUTPUTTING HALFTONE PLATE, HALFTONE PLATE, AND PRINTED MATERIAL

BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention relates to a method of tone reproduction with halftone dots, an apparatus for outputting a halftone plate, a halftone plate, and a printed material, which are suitable for application to a printing press, a CTP (Computer To Plate) system, a CTC (Computer To Cylinder) system, a DDCP (Direct Digital Color Proofing) system, a film setter, etc. which are halftone dot image outputting apparatus for generating a multicolor-separated halftone dot image in the graphic arts fields, to prevent tone jumps in halftone dot images.

Description of the Related Art:

In recent years, there have widely be used in the print platemaking field image scanning reading and recording apparatus for electrically processing the image information of a subject to produce a film plate for printing in order to make the printing operation efficient and improve the quality of images.

The image scanning reading and recording apparatus are basically constructed of an input section, a control section, and an output section. In the input section, an image signal is captured from a subject by an illuminating optical

system, a color-separating optical system, and a photometric system.

The image signal which has been photoelectrically converted by the input section is then processed by the control section for tone correction, color correction, edge emphasis, and signal conversion from R (Red), G (Green), and Blue (B) signals into C (Cyan), M (Magenta), Y (Yellow), and K (Black) signals.

The image signal which has been processed by the control section is converted by the output section into an optical signal such as a laser signal or the like, which is processed to record a signal on a recording medium that is made of a photosensitive or thermal material. The image recorded on the recording medium is developed, and the recording medium is then used for printing.

If a subject to be duplicated by printing represents a continuous-tone image such as a photograph, a painting, etc., then it is necessary to screen the subject so as to reproduce the tone of the image with halftone dots. Specifically, on a film plate, the continuous-tone image of the subject is converted to a halftone dot image that is made up of a collection of halftone dots whose sizes depend on the highlight and shadow areas of the continuous-tone image.

It is known in the art that there are available halftone dots of different shapes, e.g., circular dots, quadrilateral (square or rhomboidal) dots, dots of geometrically

mixed shapes, etc., as described in pages 68, 69, and 70 of "Postscript screening" 1st Edition, 1st Printing, written by Peter Fink, published by MDN Corporation, August 11, 1994.

FIG. 9 of the accompanying drawings shows a gradation scale 2 of rhomboidal dots whose halftone percentage continuously grows from 0 % to 100 %.

FIG. 10 of the accompanying drawings shows a gradation scale 4 of circular dots whose halftone percentage continuously grows from 0 % to 100 %.

FIG. 11 of the accompanying drawings shows a gradation scale 6 of dots of geometrically mixed shapes whose halftone percentage continuously grows from 0 % to 100 %.

In order to form images of halftone dots, it is preferable to generate halftone plates such as film plates capable of a smoother tone reproduction free of tone jumps.

In the gradation scale 2 shown in FIG. 9, square halftone dots (including rhomboidal halftone dots) range from a highlight area which is a bright area of lower density through an intermediate tone area to a shadow area which is a dark area of high density. It is known in the art that the tone reproduction of the shapes of the respective dots in the gradation scale 2 cannot be accurately performed in both the highlight area and the shadow area.

In the gradation scale 4 shown in FIG. 10, circular halftone dots range from a highlight area of lower density through an intermediate tone area to a shadow area of high density. It is known in the art that the tone reproduction

of the shapes of the respective dots in the gradation scale 4 can be accurately performed in the highlight area, but it cannot be accurately performed in the shadow area, and a tone jump occurs at halftone dot junctions in the vicinity of the halftone percentage of 78.5 %.

In the gradation scale 6 shown in FIG. 11, a highlight area is composed of circular halftone dots, an intermediate tone area at the halftone percentage of 50 % is composed of square halftone dots, and a shadow area is composed of dots that are in symmetrically shaped relation to the dots in the highlight area across the halftone percentage of 50 %. In the gradation scale 6, the tone reproduction of the shapes of the respective dots can be accurately performed in both the highlight area and the shadow area, and the gradation changes smoothly up to the halftone percentage of 50 %. However, the gradation scale 6 made up of dots of geometrically mixed shapes is disadvantageous in that a large tone jump occurs in the vicinity of the halftone percentage of 50 %.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a method of tone reproduction with halftone dots, an apparatus for outputting a halftone plate, a halftone plate, and a printed material, which are capable of eliminating tone jumps in all areas ranging from a highlight area through an intermediate tone area to a shadow area for

thereby achieving a smoother tone reproduction.

In a method of tone reproduction of an image with halftone dots, the halftone dots are grown in a circular or elliptical shape in a first transformation zone from a halftone percentage of 0 % to a first highlight percentage, grown while changing from the circular or elliptical shape to a square or rhomboidal shape in a second transformation zone from the first highlight percentage to a second highlight percentage greater than the first highlight percentage, grown in a square or rhomboidal shape in a third transformation zone from the second highlight percentage to a second shadow percentage, grown while changing from the square or rhomboidal shape to a circular or elliptical shape in a fourth transformation zone from the second shadow percentage to a first shadow percentage greater than the second shadow percentage, and grown in a circular or elliptical shape in a fifth transformation zone from the first shadow percentage to a percentage of 100 %.

With the above arrangement, the tone reproduction of the shapes of the dots can be accurately performed in the highlight area and the shadow area, and no tone jumps occur in the vicinity of the halftone percentages of 50 % and 78.5 %.

The second highlight percentage may be at most 48 % and the second shadow percentage may be at least 52 %.

When the halftone dots are grown in the square or rhomboidal shape, they are preferably successively grown along

each of the sides thereof while minimizing any displacement of the center of gravity of the halftone dots, for preventing tone jumps from occurring.

The present invention is also applicable to an apparatus for outputting a halftone plate.

The present invention is also applicable to a halftone plate expressing highlight and shadow areas of a subject with sizes of halftone dots.

The present invention is also applicable to a printed material expressing highlight and shadow areas of a subject with sizes of halftone dots.

The above and other objects, features, and advantages of the present invention will become apparent from the following description when taken in conjunction with the accompanying drawings in which preferred embodiments of the present invention are shown by way of illustrative example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a basic arrangement of a print platemaking system based on the principles according to the present invention;

FIG. 2 is a diagram showing, by way of example, the manner in which the shape of a halftone dot grows according to the embodiment of the present invention;

FIG. 3 is an enlarged diagram showing a combination of growth phases of the halftone dot shape shown in FIG. 2;

FIG. 4 is a diagram showing the manner in which a half-

tone dot of geometrically mixed shapes grows according to the prior art;

FIG. 5 is a diagram showing the manner in which a half-tone dot grows in increments of quadrilateral dots in one example;

FIG. 6 is a diagram showing the manner in which a half-tone dot grows in increments of quadrilateral dots in another example;

FIG. 7 is a diagram showing a gradation scale according to an embodiment of the present invention;

FIG. 8 is a diagram showing a gradation scale according to another embodiment of the present invention;

FIG. 9 is a diagram showing a conventional gradation scale of rhomboidal dots;

FIG. 10 is a diagram showing a conventional gradation scale of circular dots; and

FIG. 11 is a diagram showing a conventional gradation scale of geometrically mixed shapes.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows in block form a print platemaking system 10 based on the principles according to the present invention.

As shown in FIG. 1, the print platemaking system 10 basically comprises an image input section 12, a control section 14, a plate output section 16, and a printing section 18. The print platemaking system 10 is a system for output-

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ting a film plate F and a presensitized plate M, each as a
halftone plate having a halftone dot image representing a
continuous-tone image read from a subject 20, and a printed
material P. Each of the film plate F, the presensitized
plate M, and the printed material P functions as an image
reproduction medium because it is a medium representing the
halftone dot image representing the continuous-tone image
read from the subject 20.

The image input section 12 comprises a scanner 22 in
the illustrated embodiment. In the scanner 22, the subject
20 which is irradiated with light from a light source while
being fed in an auxiliary scanning direction reflects or
passes the light, which is guided to a photoelectric trans-
ducer such as a CCD linear image sensor or the like. The
photoelectric transducer electrically scans the subject 20
in a main scanning direction perpendicular to the auxiliary
scanning direction, thereby scanning the subject 20 two-
dimensionally. As the subject 20 is scanned two-
dimensionally, the light reflected by or passing through the
subject 20 is converted into an electric analog image signal
(pixel signal) by the photoelectric transducer.

The analog image signal, which represents the two-
dimensional image of the subject 20, is converted by an A/D
converter into digital image data (digital image signals)
for R (Red), G (Green), and B (Blue), which are outputted
from the image input section 12, i.e., the scanner 22.

The image input section 12 is not limited to the scan-

ner 22, but may comprise any medium for outputting digital image data, e.g., an image recording disk (image recording medium), such as a DVD (Digital Video Disk) or the like, a communication network, a digital still camera, or the like.

The control section 14 comprises a computer 24 as an image processor and a RIP (Raster Image Processor) 26 for converting digital image data G outputted from the computer 24 into binary image data (binary scanning image data) H or multivalued image data (multivalued scanning image data), such as quarternary image data, for producing halftone dots.

The RIP 26 outputs binary image data H for turning on and off a laser beam to selectively blacken or unblacken the film plate F or the presensitized plate M, as described later on. A multivalued halftone dot image, such as a quarternary halftone dot image, may be formed on the film plate F or the like by varying a laser drive current, for example.

The computer 24 of the control section 14 processes R, G, B digital image data supplied from the scanner 22 for color correction and sharpness, converts the R, G, B digital image data into C, M, Y, K digital image data (simply referred to as "digital image data") and also converts their resolution, and outputs the processed and converted digital image data G.

In the illustrated embodiment, the digital image data G represent four color components of C, M, Y, K (plural color components). However, if the subject 20 comprises a monochromatic subject, then the digital image data G may repre-

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sent a single color component of K.

Each of the digital image data G of C, M, Y, K has 256 gradations of respective values 0, 1, 2, $\cdots$, 255, where the value 0 is in a highlight area and the value 255 in a shadow area. The value 0 may be converted into a halftone percentage of 0 %, the value 255 a halftone percentage of 100 %, and the value 128 a halftone percentage of 50 %. The halftone percentages ranging from 0 to less than 50 % are in the highlight area, the halftone percentages ranging from over 50 % to 100 % are in the shadow area, and the halftone percentage of 50 % is in the intermediate area.

The digital image data G processed by the computer 24 is supplied to a comparison input terminal of a comparator 28 of the RIP 26, and also to an address calculator 30.

The RIP 26 comprises, in addition of the comparator 28 and the address calculator 30, a supercell threshold template (also referred to as "threshold matrix" or "halftone dot threshold data") 32 as a storage unit, and a halftone attribute input unit 34.

The address calculator 30 calculates an address AD = AD (x, y) representing X- and Y-axis addresses on the supercell threshold template 32 from each address of the digital image data (pixel data) G supplied from the computer 24, and supplies the calculated address to the supercell threshold template 32.

A threshold value (either one of threshold data of the 256 gradations of respective values 0, 1, 2, $\cdots$, 255) T

stored in the designated address AD of the supercell threshold template 32 is read and supplied to a reference input terminal of the comparator 28.

The supercell threshold template 32 that is used corresponds to halftone attributes (screen ruling, screen angle, and screen shape) designated by the halftone attribute input unit 34.

A supercell comprises a plurality of dots (also referred to as "dot cells"). In the field of halftone dot generating technology, generally, a supercell is established on a pixel grid (which refers to a cluster of pixels, each as a unit to be blackened, that are arranged in a regular array of pixels in horizontal rows and vertical columns depending on the output resolution) determined by the output resolution), the established supercell is broken up into halftone dot cells, and a threshold value is assigned to each of the pixels in the divided halftone dot cells, so that halftone dot thresholds are generated. A supercell composed of plural halftone dot cells to which threshold values are assigned is referred to as the supercell threshold template 32. Each of the halftone dot cells to which threshold values are assigned is referred to as a threshold template or a threshold matrix.

As described later on, the present invention resides in the assignment of a threshold value to a threshold template, or stated otherwise, the manner in which halftone dots are grown.

The book "Postscript screening" described above may be
used as a reference work for the technology for generating
halftone dots in relation to a supercell.

The concept of a supercell composed of plural halftone
dot cells makes it possible to vary the screen ruling and
the screen angle by smaller degrees, allowing the selection
of values closer to the screen ruling and the screen angle
that are designated.

The comparator 28 compares the digital image data G and
a threshold value T with each other to determine $G \geq T \rightarrow 1$
(laser beam on for blackening a dot) or $G < T \rightarrow 0$ (laser
beam off for unblackening or blanking a dot), and outputs
binary halftone dot image data (also referred to as "binary
data", "binary image data", "halftone dot image data",
"halftone dot gradation data" or "digital halftone dot
data") H having a value 1 or a value 0 depending on the re-
sult of the comparison.

The halftone dot image data H generated by the RIP 26
is supplied to a film setter 36 or a CTP system 38 of the
plate output section (also referred to as "halftone plate
output section") 16. The halftone dot image data H is also
supplied to a printing press 42 which also functions as a
CTC system.

The plate output section 16 is constructed of the film
setter 36, the CTP system 38, or an exposure/development de-
vice 40.

The film setter 36 as a halftone plate output device

scans and exposes an unexposed film to a laser beam that is selectively turned on and off, i.e., modulated, based on the halftone dot image data H, thereafter develops a halftone dot image on the film, and outputs the film as a film plate F as a halftone plate with the halftone dot image formed thereon.

Then, the exposure/development device 40 as a halftone plate output device includes an exposure unit in which a PS blank plate is superposed on the film plate F closely thereto and exposed to analog light emitted from a light source and passing through the film plate F, and a development unit in which a halftone dot image on the PS blank plate is developed to generate a presensitized plate M as a halftone plate with the developed halftone dot image formed thereon.

The CTP system 38 generates a presensitized plate M directly from the halftone dot image data H outputted from the RIP 26.

The presensitized plate M is mounted as a printing plate on the printing press 42 of the printing section 18 as an apparatus for producing a printed material.

If the printing press 42 comprises a digital printing press that functions as a CTC system for exposing a printing plate blank wound around an internal cylinder directly to a laser beam to produce a printing plate as a halftone plate, then the printing press 42 produces a printing plate as a halftone plate directly from the halftone dot image data H, as shown by a route indicated by CTC in FIG. 1.

In the printing press 42, an ink is applied to the mounted printing plate, and then transferred from the printing plate to a sheet such as a print sheet, thus producing a desired printed material P with an image formed thereon.

Actually, printing plates for the colors C, M, Y, K are produced, and mounted on respective cylinders. Inks of those colors are applied to the mounted printing plates, and then transferred from the printing plates to a sheet such as a print sheet, thus producing a desired printed material P with a color image formed thereon.

The shape of a halftone dot formed on the film plate F, the presensitized plate M, or the printed material P based on each of the threshold templates (each threshold matrix) of the supercell threshold template 32 will be described below.

FIG. 2 shows, by way of example, the manner in which the shape of a halftone dot grows on the film plate F, the presensitized plate M, or the printed material P, based on the halftone dot image data H as converted into halftone percentages, according to the embodiment of the present invention.

In FIG. 2, when the halftone percentage is 0 %, a halftone dot 50a is not blackened at all.

In a first transformation zone 101 from a halftone percentage of 0 % to a first highlight percentage HL1, the halftone dot 50a changes to a halftone dot 50b where the dot grows in a circular (or elliptical) shape (first halftone

dot generating means).

In a second transformation zone 102 from the first highlight percentage HL1 to a second highlight percentage HL2, the halftone dot 50b grows to a halftone dot 50c where the dot changes from the circular or elliptical shape to a quadrilateral (square or rhomboidal) shape (second halftone dot generating means).

Then, in a third transformation zone 103a, 103b from the second highlight percentage HL2 via an intermediate halftone percentage of 50 % to a second shadow percentage SD2, the halftone dot 50c changes to halftone dots 50d, 50e where the dot grows in a quadrilateral shape (third halftone dot generating means).

In a fourth transformation zone 104 from the second shadow percentage SD2 to a first shadow percentage SD1 whose halftone percentage is greater than the second shadow percentage SD2, the halftone dot 50e changes to a halftone dot 50f where the dot changes from the quadrilateral shape to a circular (or elliptical) shape (fourth halftone dot generating means).

Finally, in a fifth transformation zone 105 from the first shadow percentage SD1 to the halftone percentage of 100 %, the halftone dot 50f changes to a halftone dot 50g where the dot grows in a circular (or elliptical) shape (fifth halftone dot generating means).

Threshold values of each of the threshold templates of the supercell threshold template 32 may be arranged so as to

achieve the halftone dot growth shapes shown in FIG. 2. The array of threshold values which determines a halftone dot shape may be described by the spot function of the postscript language. The supercell threshold template 32 and the spot function provide the first through fifth halftone dot generating means.

FIG. 3 shows a combination of growth phases of the halftone dot shape shown in FIG. 2.

In FIG. 3, a halftone dot 60 shown hatched represents an actual blackened shape of a circular dot (composed of 29 dots = 25 dots + 4 dots), and is schematically indicated as a circular halftone dot 60A. In this embodiment, a halftone dot 51 is grown in a successively blackened sequence from the circular halftone dot 60A in the highlight area to a circular halftone dot 60B in the highlight area to a quadrilateral halftone dot 60C in the highlight area to a quadrilateral halftone dot 60D (whose halftone percentage is 50 %) to a quadrilateral halftone dot 60E in the shadow area to a circular halftone dot 60F in the shadow area to a circular halftone dot 60G in the shadow area.

FIG. 4 shows a halftone dot 52 of geometrically mixed shapes grows according to the prior art for comparison purposes. In FIG. 4, the halftone dot 52 is grown in a successively blackened sequence from the circular halftone dot 60A (more accurately, the halftone dot 60) in the highlight area to the circular halftone dot 60B in the highlight area to a circular halftone dot 60C' in the highlight area to the

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quadrilateral halftone dot 60D (whose halftone percentage is 50 %) to a circular halftone dot 60E' in the shadow area to the circular halftone dot 60F in the shadow area to the circular halftone dot 60G in the shadow area. The halftone dots 60C, 60E shown by the dotted lines are the same as the halftone dots 60C, 60E according to the present invention shown in FIG. 3.

FIG. 5 shows the manner in which, in the halftone dot 51 shown in FIG. 3, the quadrilateral halftone dot 60C in the highlight area is grown into the quadrilateral halftone dot 60D (whose halftone percentage is 50 %) and then into the quadrilateral halftone dot 60E in the shadow area, i.e., the halftone dot is grown from the second highlight percentage HL2 (see the quadrilateral halftone dot 50c in FIG. 2) via the intermediate halftone percentage of 50 % into the second shadow percentage SD2 (see the quadrilateral halftone dot 50e in FIG. 2) in the third transformation zone 103a, 103b. In FIG. 5, the number of dots is fewer than the number of dots in FIG. 3 for an easier understanding of the present invention.

In FIG. 5, a substantially quadrilateral halftone dot 62a of point symmetry which is composed of 13 blackening dots is grown first into a halftone dot 62b by successively adding blackening dots 63, 64, 65 in the order indicated by the arrow along a side (lower left side in FIG. 5) of the halftone dot (threshold values of the supercell threshold template 32 for generating the blackening dots 63, 64, 65

are progressively greater in the sequence of the blackening

dots 63, 64, 65), and then into a halftone dot 62c by suc-

cessively adding blackening dots 66, 67, 68 in the order in-

dicated by the arrow along an opposite side (upper right

side in FIG. 5) of the halftone dot. Then, the halftone dot

62c is grown into a halftone dot 62d by successively adding

blackening dots 69, 70, 71 in the order indicated by the ar-

row along a remaining side (lower right side in FIG. 5) of

the halftone dot, and then into a halftone dot 62e by suc-

cessively adding blackening dots 72, 73, 74 in the order in-

dicated by the arrow along a remaining opposite side (upper

left side in FIG. 5) of the halftone dot. The halftone dot

62c and the quadrilateral halftone dot 62e are of a shape of

point symmetry. When the halftone dot is grown in the man-

ner shown in FIG. 5, any displacement of the center of grav-

ity of the halftone dot is minimum. Since the halftone dot

is grown along each side thereof, the tone reproduction of

the shape of the dot can be accurately performed in the

printing process.

FIG. 6 shows the manner in which a halftone dot is

grown in a quadrilateral (square or rhomboidal) shape suc-

cessively along sides thereof with a minimum displacement of

the center of gravity thereof, in another example.

In FIG. 6, a quadrilateral (square) halftone dot 80a

which is composed of 9 blackening dots is grown first into a

halftone dot 80b by successively adding blackening dots from

the left to the right in the order indicated by the arrow

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along a lower side of the halftone dot, then into a halftone

dot 80c by successively adding blackening dots from the

right to the left in the order indicated by the arrow along

an upper side of the halftone dot, thereafter into a half-

tone dot 80d by successively adding blackening dots upwardly

in the order indicated by the arrow along a right side of

the halftone dot, and finally into a halftone dot 80e by

successively adding blackening dots downwardly in the order

indicated by the arrow along a left side of the halftone

dot. The halftone dot 80e is of a square shape. The half-

tone dot can further be grown in the same manner as de-

scribed above. When the halftone dot is grown in the manner

shown in FIG. 6, since the halftone dot is also grown along

each side thereof, the tone reproduction of the shape of the

dot can be accurately performed in the printing process.

FIGS. 7 and 8 show gradation scales 82, 84 according to

different embodiments of the present invention. The grada-

tion scale 82 is produced based on the halftone dot growth

shown in FIG. 2, and the gradation scale 84 is produced

based on the halftone dot growth shown in FIG. 2 except that

those halftone dots grown in a circular shape in the grada-

tion scale 82 are grown in an elliptical shape. Specifi-

cally, the halftone dots of the gradation scales 82, 84 are

grown in the following sequence (1) - (5):

(1) In the first transformation zone 101 from the half-

tone percentage of 0 % to the first highlight percentage HL1

(HL1 = 25 % in this example), the halftone dot is grown in a

circular shape as shown in FIG. 7 or an elliptical shape as shown in FIG. 8 (first halftone plate section, first print section).

(2) In the second transformation zone 102 from the first highlight percentage HL1 to the second highlight percentage HL2 (HL2 = 32 % in this example), the halftone dot is grown from the circular or elliptical shape into a square shape as shown in FIG. 7 or a rhomboidal shape as shown in FIG. 8 (second halftone plate section, second print section).

(3) In the third transformation zone 103a, 103b from the second highlight percentage HL2 to the second shadow percentage SD2 (SD2 = 68 % in this example), the halftone dot is grown in a square shape as shown in FIG. 7 or a rhomboidal shape as shown in FIG. 8 (third halftone plate section, third print section).

(4) In the fourth transformation zone 104 from the second shadow percentage SD2 to the first shadow percentage SD1 (SD1 = 75 % in this example), the halftone dot is grown from the square or rhomboidal shape into a circular shape as shown in FIG. 7 or into an elliptical shape as shown in FIG. 8 (fourth halftone plate section, fourth print section).

(5) In the fifth transformation zone 105 from the first shadow percentage SD1 to the halftone percentage of 100 %, the halftone dot is grown in a circular shape as shown in FIG. 7 or an elliptical shape as shown in FIG. 8 (fifth halftone plate section, fifth print section).

When the halftone dot is grown according the embodiments described above, the tone reproduction of the shapes of the respective dots can be accurately performed in the highlight area and clearly define inter-dot spaces in the shadow area, and no tone jumps occur in the vicinity of the halftone percentages of 50 % and 78.5 % when the film plate F, the presensitized plate M, and the printed material P are produced.

According to the present invention, as described above, tone jumps are eliminated from all areas ranging from the highlight area through the intermediate tone area to the shadow area, making it possible to achieve a smoother tone reproduction.

Although certain preferred embodiments of the present invention have been shown and described in detail, it should be understood that various changes and modifications may be made therein without departing from the scope of the appended claims.

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What is claimed is:

1. A method of tone reproduction of an image with half-
tone dots by forming dots arranged at regular intervals and
having different sizes on an image reproduction medium based
on a binary or multivalued image out of digital image data
representing a single color component or a plurality of
color components, comprising the steps of:

growing the halftone dots in a circular or elliptical
shape in a first transformation zone from a halftone per-
centage of 0 % to a first highlight percentage;

growing the halftone dots while changing from the cir-
cular or elliptical shape to a square or rhomboidal shape in
a second transformation zone from the first highlight per-
centage to a second highlight percentage greater than said
first highlight percentage;

growing the halftone dots in a square or rhomboidal
shape in a third transformation zone from the second high-
light percentage to a second shadow percentage;

growing the halftone dots while changing from the
square or rhomboidal shape to a circular or elliptical shape
in a fourth transformation zone from the second shadow per-
centage to a first shadow percentage greater than said sec-
ond shadow percentage; and

growing the halftone dots in a circular or elliptical
shape in a fifth transformation zone from said first shadow
percentage to a percentage of 100 %.

2. A method according to claim 1, wherein said second highlight percentage is at most 48 % and said second shadow percentage is at least 52 %.

3. A method according to claim 1, wherein when the halftone dots are grown in the square or rhomboidal shape, they are successively grown along each of the sides thereof while minimizing any displacement of the center of gravity of the halftone dots.

4. An apparatus for outputting a halftone plate of halftone dots, comprising:

first halftone dot generating means for growing the halftone dots in a circular or elliptical shape in a first transformation zone from a halftone percentage of 0 % to a first highlight percentage;

second halftone dot generating means for growing the halftone dots while changing from the circular or elliptical shape to a square or rhomboidal shape in a second transformation zone from the first highlight percentage to a second highlight percentage greater than said first highlight percentage;

third halftone dot generating means for growing the halftone dots in a square or rhomboidal shape in a third transformation zone from the second highlight percentage to a second shadow percentage;

fourth halftone dot generating means for growing the

halftone dots while changing from the square or rhomboidal shape to a circular or elliptical shape in a fourth transformation zone from the second shadow percentage to a first shadow percentage greater than said second shadow percentage; and

fifth halftone dot generating means for growing the halftone dots in a circular or elliptical shape in a fifth transformation zone from said first shadow percentage to a percentage of 100 %.

5. An apparatus according to claim 4, wherein said second highlight percentage is at most 48 % and said second shadow percentage is at least 52 %.

6. An apparatus according to claim 4, wherein when the halftone dots are grown in the square or rhomboidal shape, they are successively grown along each of the sides thereof while minimizing any displacement of the center of gravity of the halftone dots.

7. A halftone plate expressing highlight and shadow areas of a subject with sizes of halftone dots, comprising:

a first halftone plate section with the halftone dots formed in a circular or elliptical shape in a first transformation zone from a halftone percentage of 0 % to a first highlight percentage;

a second halftone plate section with the halftone dots

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grown while changing from the circular or elliptical shape
to a square or rhomboidal shape in a second transformation
zone from the first highlight percentage to a second high-
light percentage greater than said first highlight percent-
age;

a third halftone plate section with the halftone dots
formed in a square or rhomboidal shape in a third transfor-
mation zone from the second highlight percentage to a second
shadow percentage;

a fourth halftone plate section with the halftone dots
grown while changing from the square or rhomboidal shape to
a circular or elliptical shape in a fourth transformation
zone from the second shadow percentage to a first shadow
percentage greater than said second shadow percentage; and

a fifth halftone plate section with the halftone dots
formed in a circular or elliptical shape in a fifth trans-
formation zone from said first shadow percentage to a per-
centage of 100 %.

8. A halftone plate according to claim 7, wherein said
second highlight percentage is at most 48 % and said second
shadow percentage is at least 52 %.

9. A halftone plate according to claim 7, wherein when
the halftone dots are grown in the square or rhomboidal
shape, they are successively grown along each of the sides
thereof while minimizing any displacement of the center of

gravity of the halftone dots.

10. A printed material expressing highlight and shadow areas of a subject with sizes of halftone dots, comprising:

a first print section with the halftone dots formed in a circular or elliptical shape in a first transformation zone from a halftone percentage of 0 % to a first highlight percentage;

a second print section with the halftone dots grown while changing from the circular or elliptical shape to a square or rhomboidal shape in a second transformation zone from the first highlight percentage to a second highlight percentage greater than said first highlight percentage;

a third print section with the halftone dots formed in a square or rhomboidal shape in a third transformation zone from the second highlight percentage to a second shadow percentage;

a fourth print section with the halftone dots grown while changing from the square or rhomboidal shape to a circular or elliptical shape in a fourth transformation zone from the second shadow percentage to a first shadow percentage greater than said second shadow percentage; and

a fifth print section with the halftone dots formed in a circular or elliptical shape in a fifth transformation zone from said first shadow percentage to a percentage of 100 %.

11. A printed material according to claim 10, wherein said second highlight percentage is at most 48 % and said second shadow percentage is at least 52 %.

5   12. A printed material according to claim 10, wherein when the halftone dots are grown in the square or rhomboidal shape, they are successively grown along each of the sides thereof while minimizing any displacement of the center of gravity of the halftone dots.

ABSTRACT OF THE DISCLOSURE

Tone jumps are eliminated in all areas ranging from a
highlight area through an intermediate tone area to a shadow
area for thereby achieving a smoother tone reproduction.
Halftone dots are grown in a circular shape from a halftone
percentage of 0 % to a first highlight percentage. Halftone
dots are grown while changing from the circular shape to a
square shape from the first highlight percentage to a second
highlight percentage greater than the first highlight per-
centage. Halftone dots are grown in a square shape from the
second highlight percentage to a second shadow percentage.
Halftone dots are grown while changing from the square shape
to a circular shape from the second shadow percentage to a
first shadow percentage greater than the second shadow per-
centage. Halftone dots are grown in a circular shape from
the first shadow percentage to a percentage of 100 %. The
dots stick well to the print sheet in the highlight area and
clearly define inter-dot spaces in the shadow area, and no
tone jumps occur in the vicinity of the halftone percentages
of 50 % and 78.5 %.

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FIG. 1

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14 CONTROL SECTION

16 PLATE OUTPUT SECTION

18 PRINTING SECTION

12 IMAGE INPUT SECTION

26 RIP

28 COMPARATOR

30 ADDRESS CALCULATOR

32 SUPERCELL THRESHOLD TEMPLATE

34 HALFTONE ATTRIBUTE INPUT UNIT

24 COMPUTER

22 SCANNER

20 SUBJECT

36 FILM SETTER

38 CTP

40 EXPOSURE/DEVELOPMENT DEVICE

42 PRINTING PRESS

FILM PLATE F

PRESENSITIZED PLATE M

PRINTED MATERIAL P

CTC

G   T   AD   H

FIG. 2

FIG. 3

FIG. 4

FIG. 5

FIG.6

FIG. 7

0%   25%   50%   75%   100%

FIG. 8

0%   25%   50%   75%   100%

FIG. 9

0%   25%   50%   75%   100%

FIG. 10

0%   25%   50%   75%   100%

FIG. 11
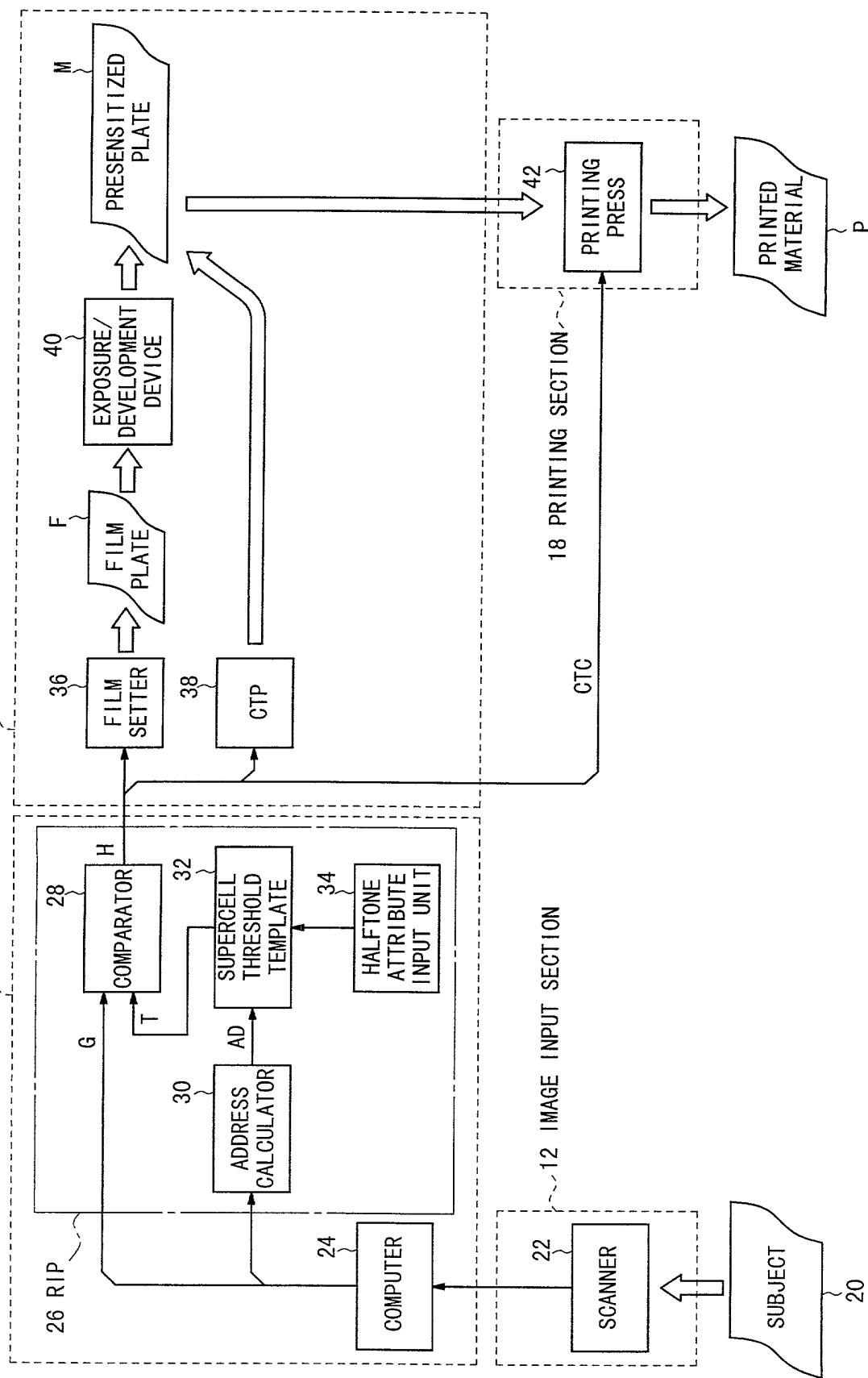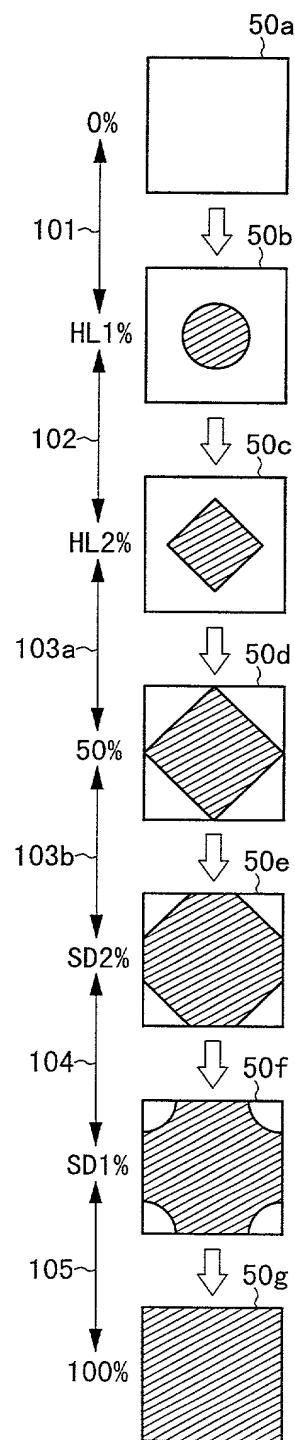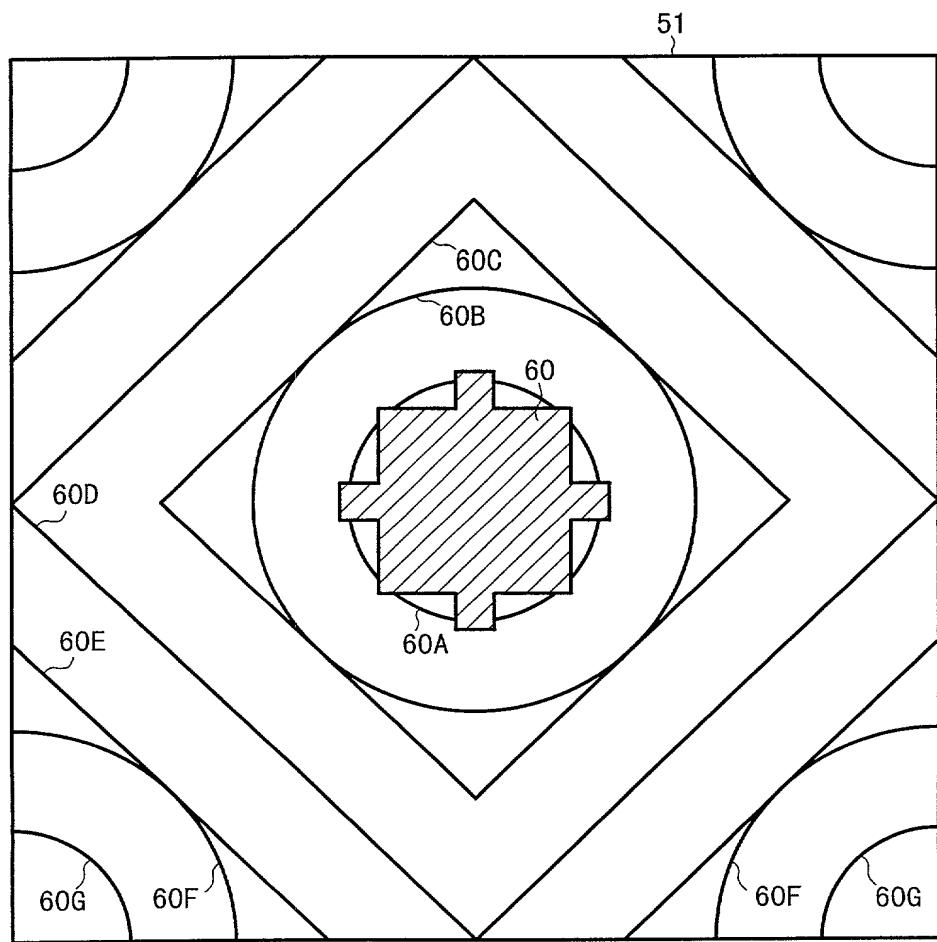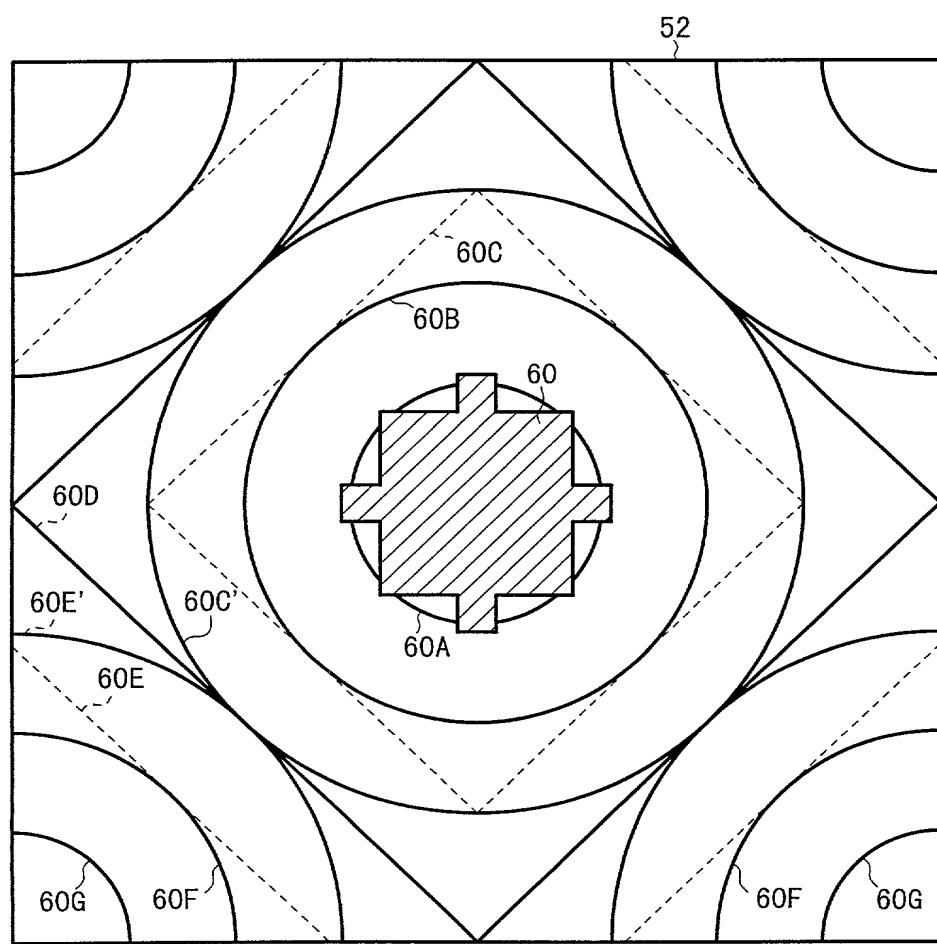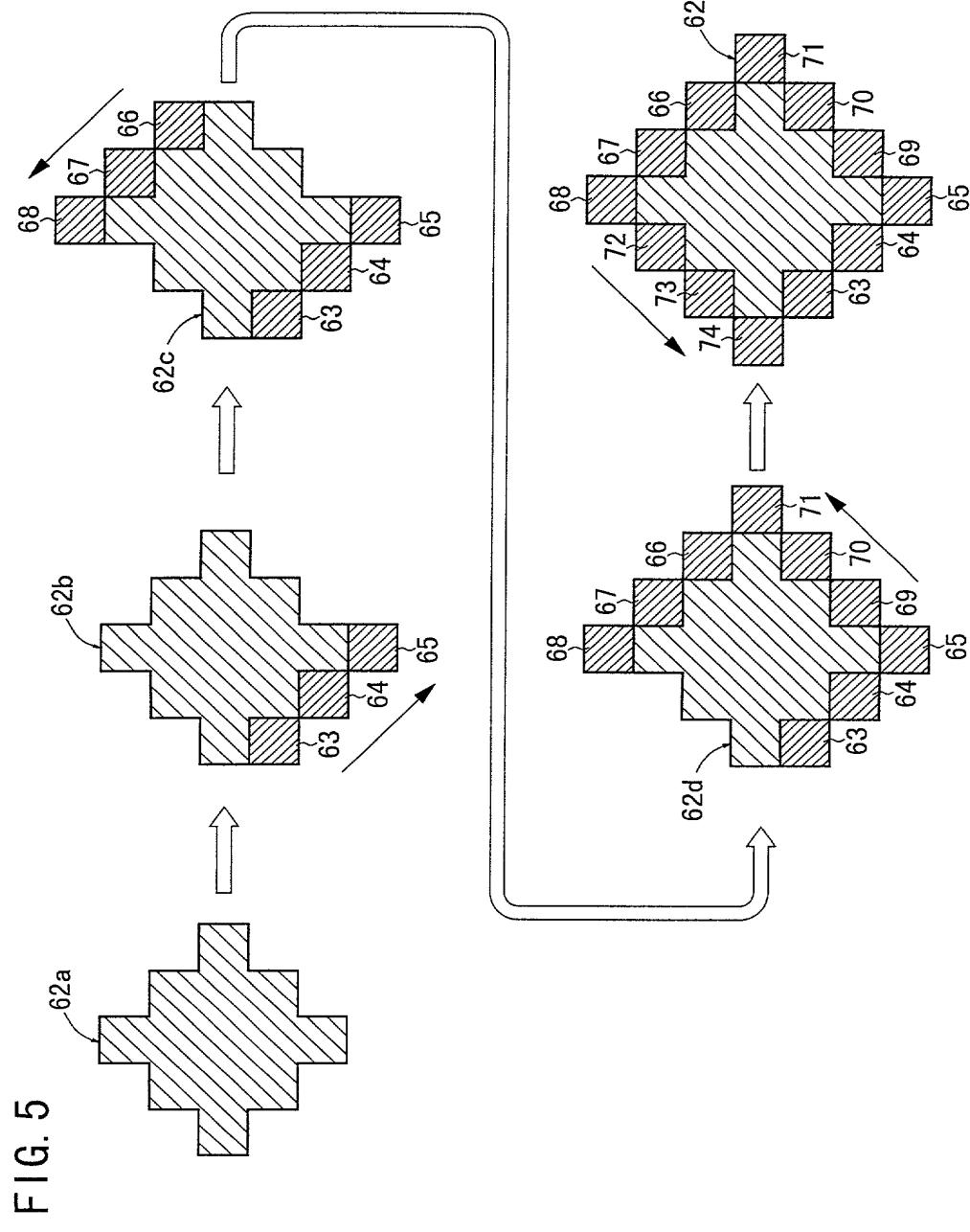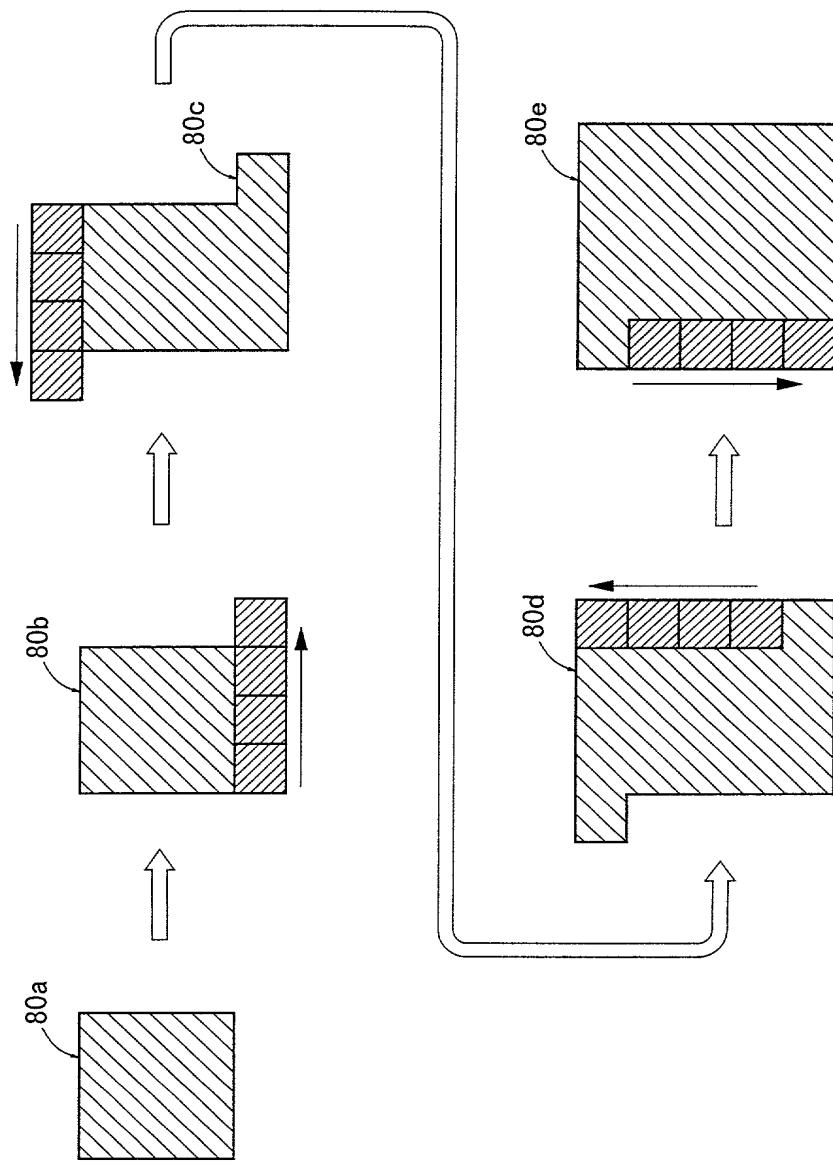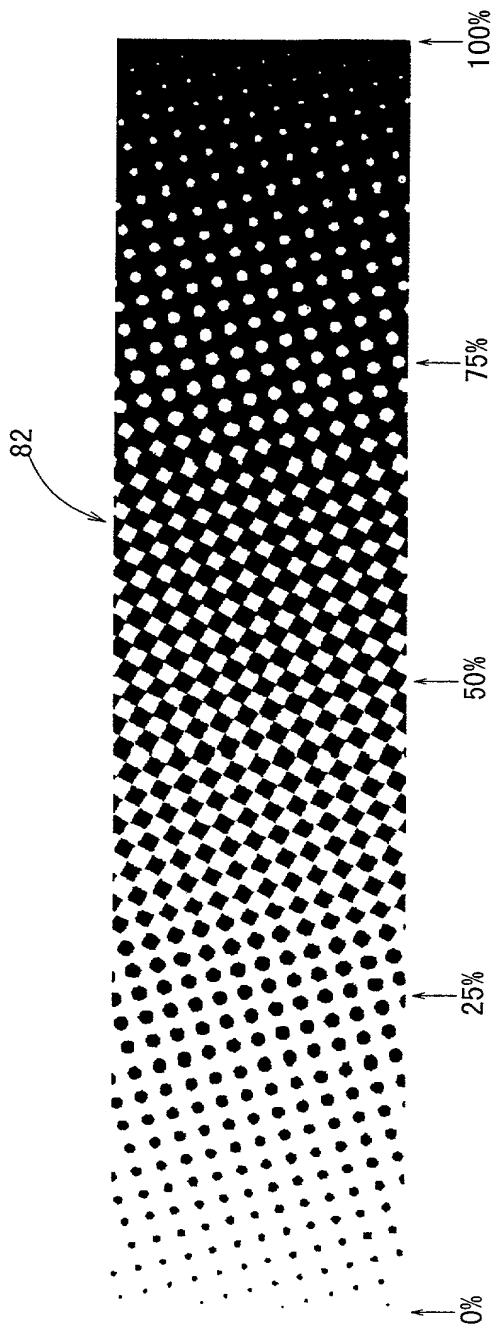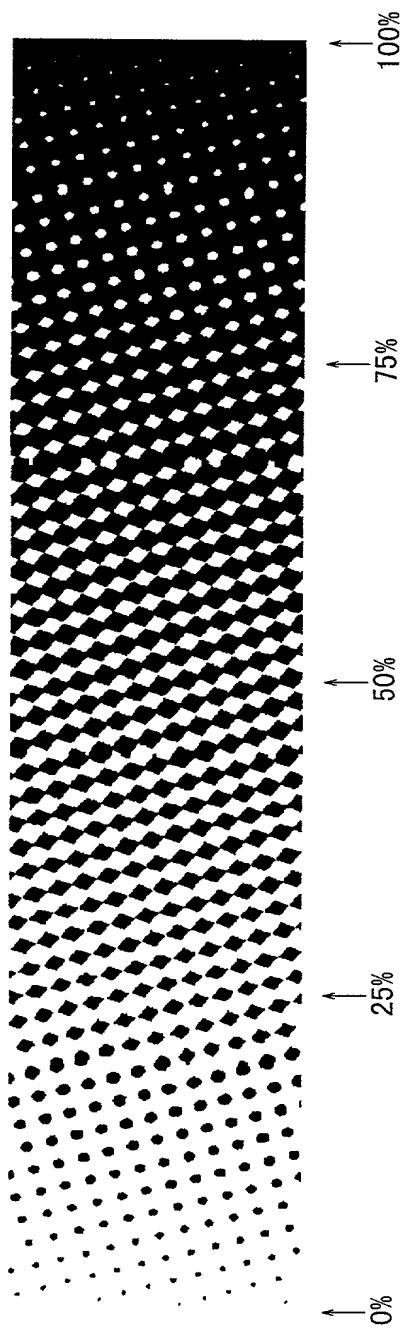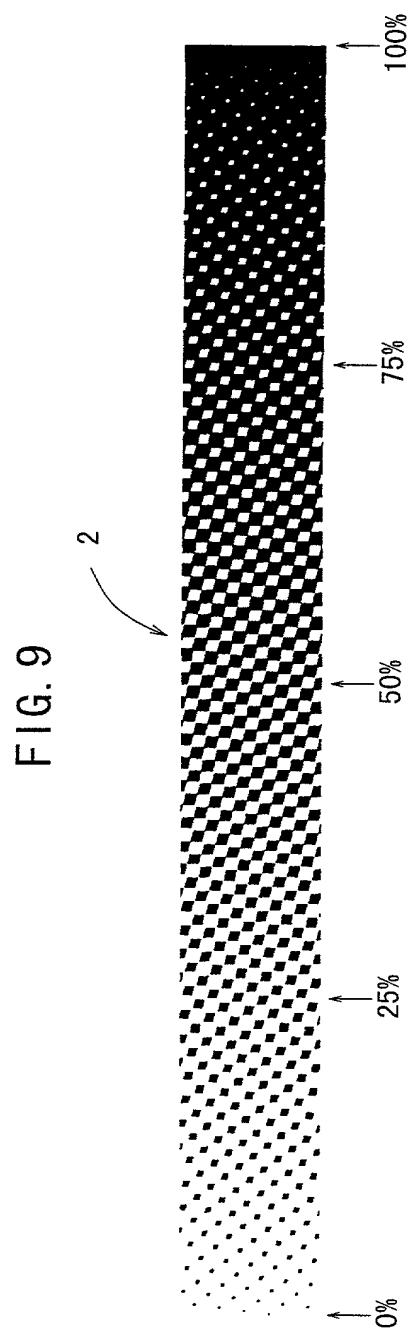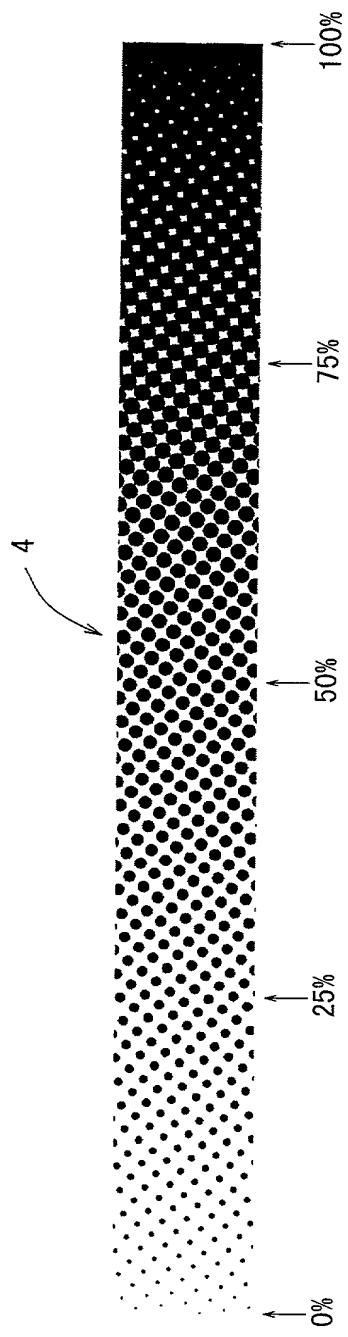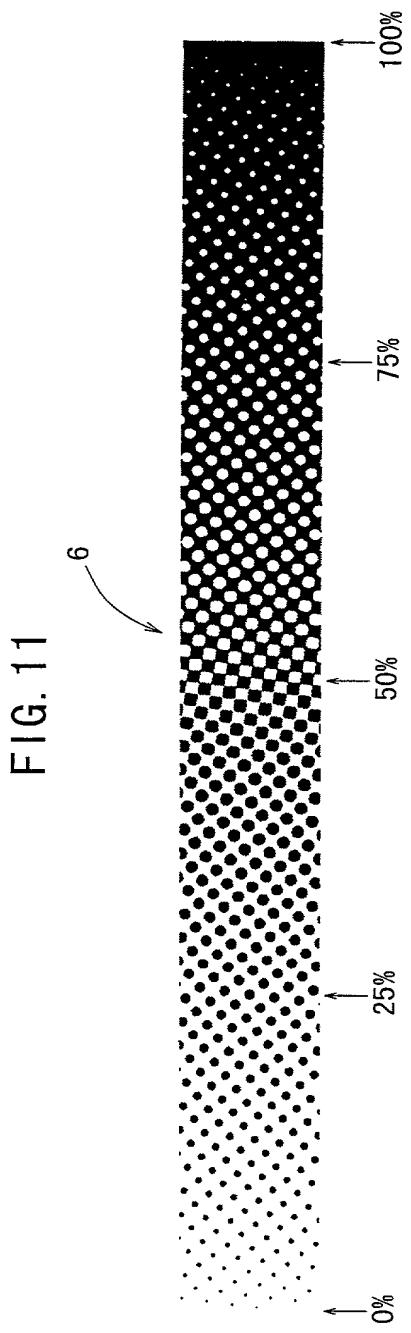
Declaration and Power of Attorney for Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name,

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

_____

_____

_____

METHOD OF TONE REPRODUCTION WITH HALFTONE DOTS,

APPARATUS FOR OUTPUTTING HALFTONE PLATE,

HALFTONE PLATE, AND PRINTED MATERIAL

上記発明の明細書（下記の欄でX印がついていない場合は、本書に添付）は、

the specification of which is attached hereto unless the following box is checked:

☐ ___月 ___日に提出され、米国出願番号または特許協定条約

国際出願番号を _____ とし、

（該当する場合）_____ に訂正されました。

☐ was filed on _____
as United States Application Number or
PCT International Application Number

_____ and was amended on

_____ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

Japanese Language Declaration
（日本語宣言書）

私は、米国法典第35編第119条(a)-(d)項又は第365条(b)項に基き下記の、米国以外の国の少なくとも一カ国を指定している特許協力条約第365条(a)項に基づく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

I hereby claim foreign priority under Title 35, United States Code, Section 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Applications
外国での先行出願

Priority Not Claimed
優先権主張なし

Patent Application No. 11-141921	Japan	21 May 1999	☐
(Number)（番号）	(Country)（国名）	(Day/Month/Year Filed)（出願年月日）	
(Number)（番号）	(Country)（国名）	(Day/Month/Year Filed)（出願年月日）	☐
(Number)（番号）	(Country)（国名）	(Day/Month/Year Filed)（出願年月日）	☐

私は、第35編米国法典119条(e)項に基づいて下記の米国特許出願規定に記載された権利をここに主張致します。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.)（出願番号）	(Filing Date)（出願日）	(Application No.)（出願番号）	(Filing Date)（出願日）

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(Application No.)（出願番号）	(Filing Date)（出願日）	(Status: Patented, Pending, Abandoned)（現況：特許許可済、係属中、放棄済）
(Application No.)（出願番号）	(Filing Date)（出願日）	(Status: Patented, Pending, Abandoned)（現況：特許許可済、係属中、放棄済）

私は、私自身の知識に基づいて本宣言中で私が行う表明が真実であり、かつ私の入手した情報と私の信ずるところに基づく表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第18編第1001条に基づき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行えば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Japanese Language Declaration
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委任状： 私は、下記の発明者として、本出願に関する一切の
手続きを米国特許商標局に対して遂行する弁理士又は代理
人として、下記のものを指名致します。（弁護士、又は代理人の
氏名及び登録番号を明記のこと）

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (*list name and registration number*)

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第二発明者の署名 日付	Second inventor's signature	Date

住所	Residence

国籍	Citizenship

郵便の宛先	Post office address

（第三以降の共同発明者についても同様に記載し、署名をするこ
と。）

(Supply similar information and signature for third and subsequent joint inventors.)